Appendix B
Reliability Study Process

B-1. A reliability analysis of hydropower plant equipment requires the following three basic steps: (a) data collection and investigations; (b) identification of specific reliability issues; and (c) calculations and evaluation. Figures B-1 and B-2 show the basic steps in a reliability study and the typical hydropower equipment analyzed for reliability.

a. The data collection and investigations need to be extensive and cover all aspects of the equipment design, use, history, and future demands. This step should include historical unit availability and operation, any equipment derating, accident reports, operation and maintenance records, equipment performance tests (original, interim, and current), periodic inspection reports, design and construction reports, the operation and maintenance manual, and turbine model test reports. During this step it is also important to identify the priorities and concerns of the project personnel and utilize engineering judgment in evaluating equipment condition. A thorough site investigation should be conducted by hydropower technical experts and should include equipment inspections and project personnel interviews.

b. The data should then be compiled and the primary equipment weaknesses and project concerns identified. The equipment condition may be quantified with the Condition Indicator (CI) value as defined in the REMR Condition Rating Procedures (USACE 1993). In addition to the CI value, the equipment operation, demands, and maintenance practices should be considered in evaluating the reliability. Experience and historical data of like equipment should be utilized in the determination of the equipment condition and future reliability.

c. Once the condition of the equipment has been identified, the calculations and evaluation should be performed. For equipment with extensive life databases, such as generators and turbines, standard time-dependent reliability and hazard functions should be used. These functions are under development by Institute for Water Resources (IWR) and HDC. Any of the weaknesses and concerns identified in the previous steps should be fully explained and addressed separately if required.

B-2. There may clearly be a failure history of specific equipment which warrants a reliability analysis separate from the remainder of the equipment. The generators at The Dalles powerhouse demonstrated a specific failure mode (coil failure from turn-to-turn faults) and a severe decline in reliability after fifteen years of age. Weibull curves were developed for the generators since the historical data of the fourteen units, for which there had been thirteen coil failures, constituted a sufficient database (USACE 1995). Specific equipment curves can be developed by adjusting the standard equipment curves if the equipment demonstrates accelerated degradation, such as was found at the Buford powerhouse. A reliability study of the Buford turbines found that the condition of the main unit turbines was typical for their age, but the station service unit showed severe degradation (USACE 1996). Therefore, it was reasonable to use the standard reliability and hazard functions for the main units and adjust these functions to reflect the poor state of the station service unit. If the equipment has a specific reliability problem but lacks a statistically significant base of data, a capacity versus demand analysis may be done. This approach was appropriate for the reliability analysis of the Walter F. George powerhouse. The turbines were found to have two areas which warranted further assessment, the shaft sleeve and hub, so JAYCOR was contracted to provide a full report (Mlaker and Bryant 1994).

B-3. To obtain the most current time-dependent reliability research results, contact the HDC.

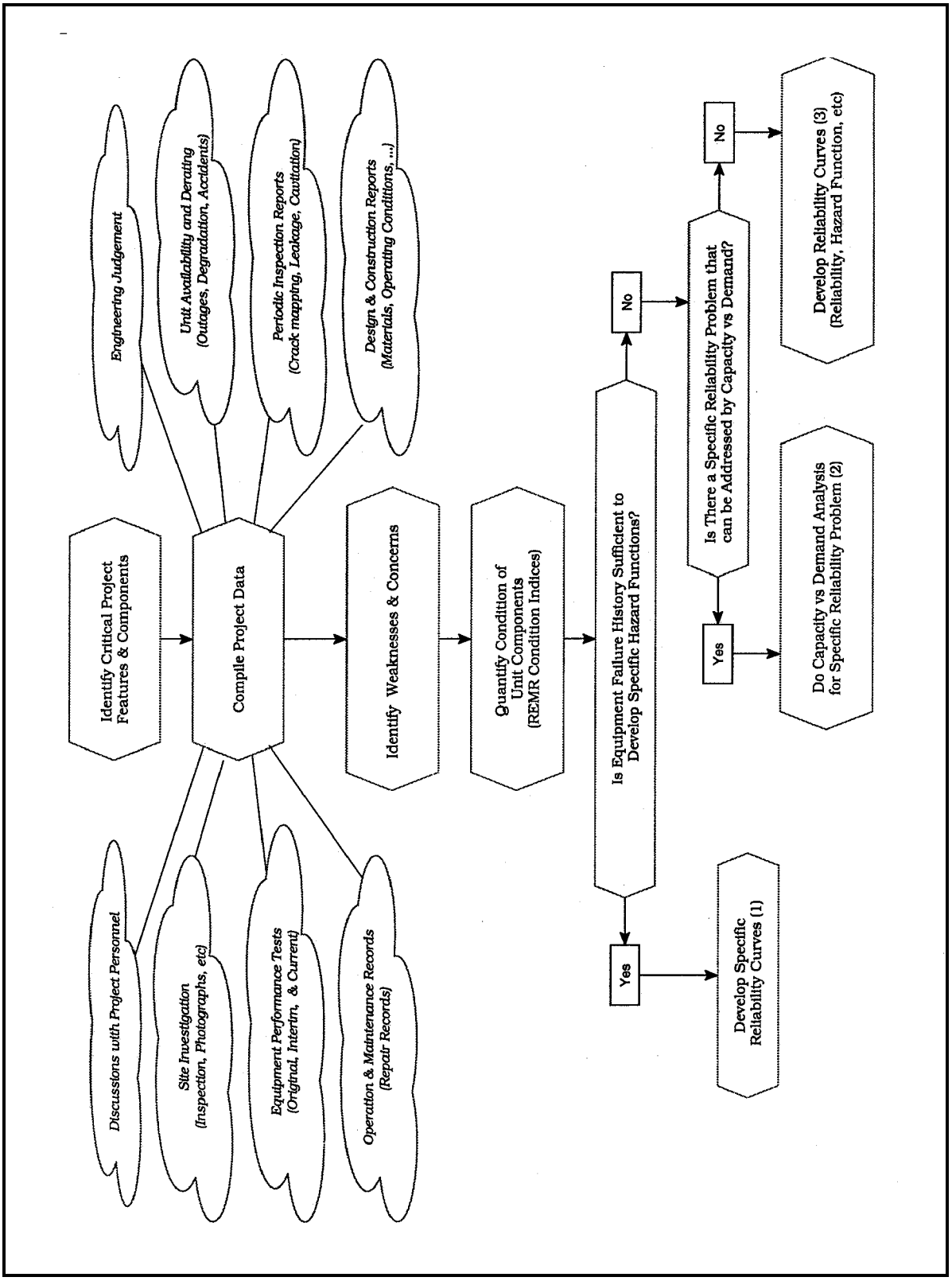

Figure B-1. General process for evaluating hydropower equipment reliability

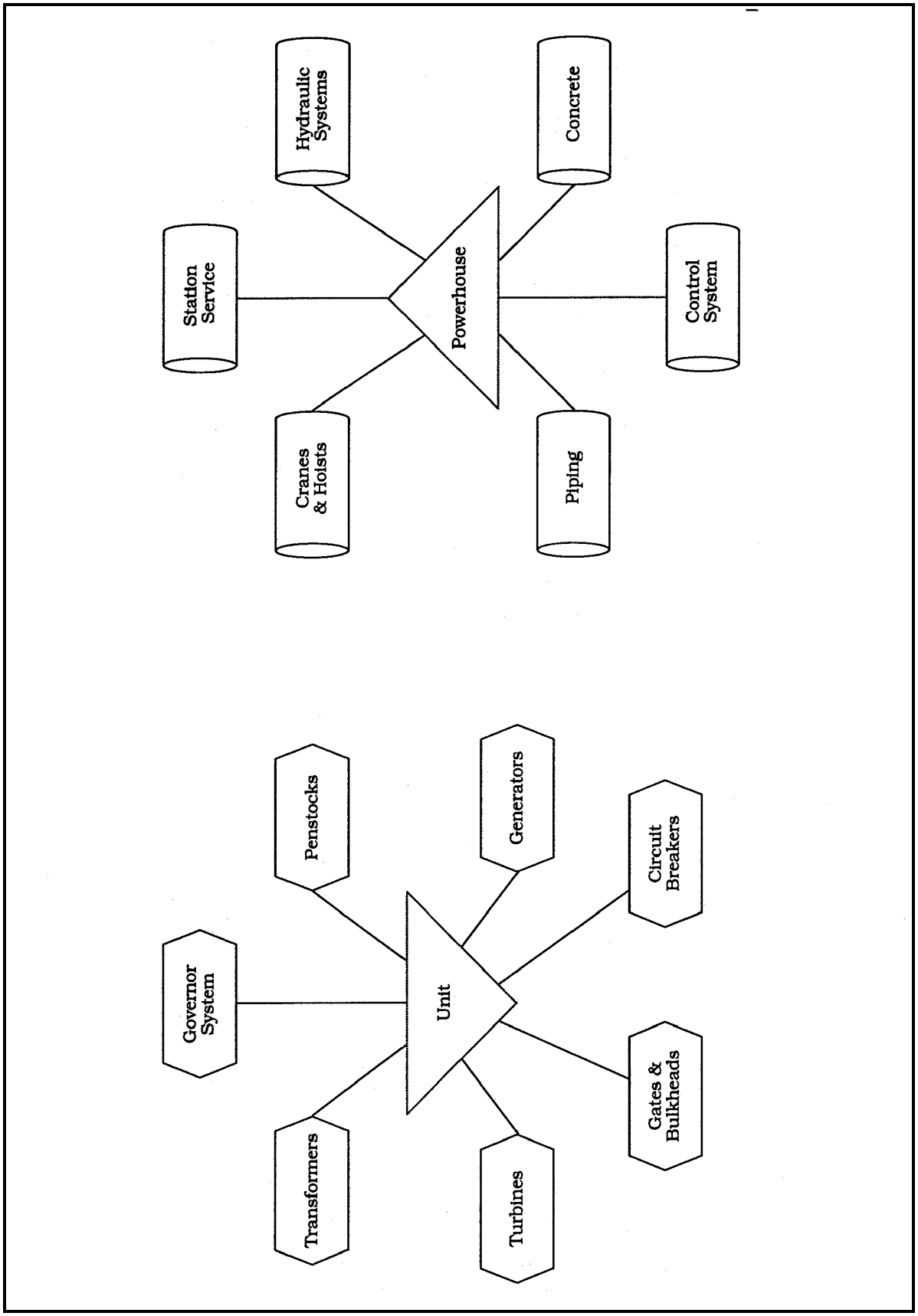

Figure B-2. Typical hydropower equipment analyzed for reliability